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16. ABSTRACT

The catalog of Industrial Process Profiles for Environmental Use was developed as an aid in defining the environmental impacts of industrial activity in the United States. Entries for each industry are in consistent format and form separate chapters of the study. The clay industry is involved in mining of clay minerals, beneficiating of clay minerals, and brickmaking. The industry is discussed in two segments: (1) Clay Production and (2) Brick Manufacture. One chemical tree, two process flow sheets and nine process descriptions have been prepared to characterize the industry. Within each process description available information has been provided on input materials, operating parameters, utility requirements and waste streams. Data related to the subject matter, including company, product and raw material data, are included as appendices.

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INDUSTRIAL PROCESS PROFILES

FOR ENVIRONMENTAL USE

CHAPTER 19

THE CLAY INDUSTRY

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TABLE OF CONTENTS

CHAPTER 19

	Page
INDUSTRY DESCRIPTION	1
Raw Materials	2
Products	3
Companies	4
Environmental Impact	7
Bibliography	8
INDUSTRY ANALYSIS	9
Clay Production Segment	11
Process No. 1. Mining	13
Process No. 2. Crushing	15
Process No. 3. Drying	17
Process No. 4. Dry Grinding	19
Process No. 5. Wet Concentrating	21
Process No. 6. Final Drying	23
Brick Manufacture Segment	25
Process No. 7. Extruding	27
Process No. 8. Brick Drying	28
Process No. 9. Firing	29
Appendix A - Raw Material List	33
Appendix B - Products List	35
Appendix C - Companies and Products	39

LIST OF FIGURES

CHAPTER 19

Figure		Page
1	Clay Industry Chemical Tree.	10
2	Clay Industry Flowsheet.	12
3	Brick Manufacture Flowsheet.	26

LIST OF TABLES

CHAPTER 19

Table		Page
1	Clay Production Statistics for 1973.	3
2	Uses of Products of the Clay Industry.	4
A-1	Raw Materials Used in 1973	34
B-1	Primary Uses of Clay Products.	36
C-1	Kaolin, Ball Clay, Fire Clay, Bentonite, and Fuller's Earth Producers.	40
C-2	Common Clay, Brick, and Structural Clay Producers.	51

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Helpful review comments from G. C. Robinson were received and incorporated into this chapter.

CLAY

INDUSTRY DESCRIPTION

For the purpose of this study the clay industry consists of companies involved in mining of clay minerals, beneficiating of clay minerals, and brickmaking. The minerals vary in chemical composition and physical properties and are difficult to define. Usually clays are natural, earthy, fine-grained, hydrated aluminum silicates which are plastic when wet, rigid when dry, and vitreous when fired.

Imprecise definitions and liberal usage and interpretation of terms make attempted classification and organization of the clay industry very difficult. The U.S. Bureau of Mines segregates the clay industry into six categories, according to clay type. The six clays are ball clay, bentonite, fire clay, fuller's earth, kaolin, and common clay plus shale. This chapter treats the clay industry in two segments: Clay Production and Brick Manufacture.

The flowsheets of Figure 2 and 3 show processes included in the industry. The first processes are mining and crushing of the clay ore. The crushed clay can be sold, or it can be extruded, dried, and fired to form bricks; or it can be dried and ground to desired fineness, or it can be separated from wastes using wet methods and then dried.

The clay industry is very fragmented. There are over 500 mining or manufacturing operations in the United States. In 1974, individual plant production capacities of finished clay product ranged from 20 to 500 metric tons per day. Approximately 60,000 persons are employed in the industry.

In 1973 approximately 58.9 x 10^6 metric tons of domestic clays valued at \$355 x 10^6 were sold or used by producers.

Clay suitable for commercial use is found in all 50 states, and in 1973 it was mined in every state except Alaska, Rhode Island, and Vermont. Leading states in clay production were Georgia with 7.0 x 10^6 metric tons, Texas with 5.2 x 10^6 metric tons, Ohio with 4.3 x 10^6 metric tons, North Carolina, Alabama, and California. Most clay mining operations are located in rural areas. Brick processing is often located in metropolitan areas.

Various types of clay are obtained from different parts of the country. Tennessee produced 63.7 percent of the total domestic ball clay in 1973. Total ball clay production in the 8 producing states was 697,000 metric tons. Bentonite totaling 2,790,000 metric tons was produced in 15 states, and the leading producer was Wyoming with 68.7 percent of the total. Fire clay totaling 3,700,000 metric tons was produced in 20 states with Ohio, Pennsylvania, Missouri, and Alabama accounting for approximately 78 percent of the total. Fuller's earth totaling 1,030,000 metric tons was produced in 9 states with

Georgia and Florida accounting for approximately 76 percent of the total. Kaolin totaling 5,450,000 metric tons was produced in 16 states with Georgia and South Carolina accounting for approximately 88 percent of the total. Common clay totaling 45,300,000 metric tons was produced in 47 states with Texas, North Carolina, Ohio, Georgia, California, Alabama, Michigan, and Pennsylvania accounting for approximately 50 percent of the total.

The clay industry is expected to grow at an annual rate of 4 percent between now and the year 2000. The demand for clay should be $155 \pm 30 \times 10^6$ metric tons in the year 2000. Present reserves are sufficient to meet the projected demand.

No information was available concerning on-site power or steam generation. It is believed that electricity is purchased from power companies.

Raw Materials

A clay is a naturally occurring sediment or sedimentary rock composed of one or more minerals and accessory compounds. The sediment is usually rich in hydrated silicates of aluminum, iron, or magnesium; hydrated alumina; or iron oxide. Most particles are of colloidal or near-colloidal size and the material commonly develops plasticity when pulverized and wetted. Further information on clay minerals is found in Appendix A.

Clay minerals are non-toxic; moreover, one of the uses of clay is in medicines and pharmaceuticals.

A serious environmental problem in the clay industry is the poor condition of abandoned or unused open-pit mines. It is believed that little effort has been made in the past to return old mines to a usable condition. In recent years, however, some states have enacted laws that require open pits to be backfilled and covered with vegetation to restore the mined-out areas. Some abandoned pits have been converted to recreational facilities: fishing lakes and at least one golf course.

Another environmental problem is waste water from processing plants that is high in suspended solids. Most states require clay producers to install settling ponds to prevent contamination of the streams.

Dust emissions in clay mining generally are not of major concern because clay is usually one-fourth water by weight. Dust emissions from stockpiled clay may occur as moisture evaporates from the clay. A few plants in or near metropolitan areas have air-pollution problems.

Products

Table 1 is a presentation of the various types of clays produced in 1973.

Table 1. CLAY PRODUCTION STATISTICS FOR 1973

Product	1973 Production (10^6 metric tons)	% of Total Clay Production	Value of Production in 1972* (10^6 $)	Number of States with Production	Leading Producing States with Production Percentages in 1973	
Common Clay and Shale	45.2	76.8	74.0	47	Texas	(10.7%)
					North Carolina	(8.3%)
					Ohio	(7.3%)
					Georgia	(5.6%)
					California	(5.1%)
					Alabama	(4.9%)
					Michigan	(4.3%)
					Pennsylvania	(4.2%)
Kaolin	5.45	9.3	136.9	16	Georgia	(75.4%)
					South Carolina	(12.6%)
Fire Clay	3.70	6.3	29.2	20	Ohio	(26.9%)
					Pennsylvania	(21.9%)
					Missouri	(20.4%)
					Alabama	(8.8%)
Bentonite	2.79	4.7	29.3	15	Wyoming	(68.7%)
					Mississippi	(9.3%)
					Montana	(5.8%)
Fuller's Earth	1.03	1.8	22.8	9	Georgia	(39.0%)
					Florida	(36.8%)
Ball Clay	0.70	1.2	10.8	8	Tennessee	(63.7%)

Table 2 lists some of the uses of products from the clay industry. A more complete duscussion of products is found in Appendix B.

Table 2. USES OF PRODUCTS OF THE CLAY INDUSTRY

PRODUCT	USES
Common Clay and Shale	brick, portland cement, lightweight aggregate, sewer pipe, tile
Kaolin	paper coating/filling, brick, rubber, firebrick, ceramics
Fire Clay	firebrick, refractory mortar/cement, high-alumina refractories, foundry sand
Bentonite	foundry sand, iron ore pelletizing, drilling mud, filtering, clarifying, decolorizing
Fuller's Earth	oil/grease absorbents, pet absorbent, pesticides
Ball Clay	sanitary ware, pottery, tile, china/ dinnerware

It should be noted that the term "common" when used in describing a type of clay is not meant to imply mediocrity or baseness. Common clay is defined by the U.S. Bureau of Mines as "a clay or claylike material which is sufficiently plastic to permit ready mold and vitrification below 1,100°C."

Companies

The clay industry is highly fragmented. Over 500 companies are included in the industry company lists of Appendix C. Most companies in the industry are primarily clay or brick producing companies.

Companies producing 85 percent of the total ball clay in 1974 were as follows.

Bell Clay Company
Cyprus Industrial Minerals
Kentucky-Tennessee Clay Co.
Old Hickory Clay Co.
Southern Clay Products, Inc.
H. C. Spinks Clay Co.

Companies producing 75 percent of the total bentonite clay in 1974 were as follows.

Americal Colloid Co.
Benton Clay Co.
Cal-Min Co.
Dresser Minerals
Filtrol Corp.
International Minerals & Chemical Corp.
McKittrick Mud Co.
NL Industries, Inc.
Western Clay Co.
Wyo-Ben Products, Inc.

Companies accounting for 50 percent of the total fire clay production in 1974 were as follows.

Cedar Heights Clay Co.
Combustion Engineering Co.
Coosa Clay Co.
Frederick J. Dando Co.
Dixie Clay Co.
Eberhart Coal, Inc.
Freeport Brick Co.
A. P. Green Refractories Co.
Harbison-Walker Refractories Co.
Kaiser Refractories
Kimble Coal Co.
Reese Bros.
Thomas Bros. Coal Co.
Union Clay Co., Inc.
Wellsville Firebrick Co.

Companies producing 75 percent of the fuller's earth clay in 1974 were as follows.

Engelhard Minerals & Chemical Corp.
Floridin Co.
Georgia-Tennessee Mining Co.
Medusa Cement Co.
Mid-Florida Mining Co.
Milwhite Co., Inc.
Oil Dri Corp. of Georgia
Thor Mining Co.
Waverly Mineral Products Co.

Companies producing 65 percent of the total kaolin in 1974 were as follows.

American Industrial Co.
Anglo-American Clays Corp.
Carolina Ceramics, Inc.
Cyprus Mines Corp.
Engelhard Minerals & Chemicals Corp.
Freeport Kaolin Co.
Georgia Kaolin Co.
J. M. Huber Corp.
National Kaolin Products Co.
Richtex Corp.
Southeastern Clay Co.
Taylor Clay Products Co.
Thiele Kaolin Co.

Companies producing approximately 20 percent of the common clay and shale in 1974 were as follows.

Barrett Industries
Bay Prairie Aggregate Corp.
Belden Brick Co.
Boren Clay Products Co.
Carolina Solite Corp.
The Claycraft Co.
The Featherlite Corp.
The Featherlite Co. of San Antonio
General Wadsworth Brick Co.
Hydraulic Press Brick Co.
Marion Brick Corp.
Pine Hall Brick and Pipe Co.
The Richland Brick Co.
Sanford Brick Co.
Solite Corp.
Strawn Materials
Superock, Inc.
Texas Industries, Inc.
Trotti & Thomson

More complete lists of producers of clays and brick are found in Appendix C.

Environmental Impact

Dust emissions in the clay industry are considered to be a minor problem. Clay usually contains 20 to 30 percent moisture and dust emissions from mining and beneficiation are minimal. Dust is released from stockpiled clay, especially bentonite, which is stockpiled for weathering. A few plants in or near metropolitan areas have air-pollution problems.

Approximately 98 percent of clay ore is mined by the open-pit method. This results in unusable land unless efforts are made to landscape the mined out areas. Unused or abandoned open-pit mines are probably the major environmental problem of the industry.

Another major environmental problem is water pollution. As overburden is removed and clay is mined, water percolates through the soil. It becomes high in suspended solids and is usually allowed to run off to streams. This problem can be alleviated if a sump or settling basin is provided for the percolating water.

Common clay has an average waste-to-clay ratio of 0.25 to 1. Kaolin has the highest waste-to-clay ratio, 7 to 1. In 1973 kaolin clay mining generated approximately 30 to 40 x 10^6 metric tons of waste while common clay mining generated approximately 10 to 15 x 10^6 metric tons of waste. It is assumed that these wastes are largely used for landfill.

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INDUSTRY ANALYSIS

Many data relating to the clay industry are available and are considered accurate. Variations in operating parameters occur because of the variety of raw materials used. Companies are believed to use the same type of equipment for mining and crushing. Only kaolin and fuller's earth are beneficiated to any appreciable extent. Beneficiating equipment for these clay minerals is believed to be basically similar.

The chemical tree of Figure 1 gives a qualitative overview of the clay industry from a raw material-end product-use standpoint. The basic products are the clays of the six basic categories - ball clay, bentonite, fire clay, fuller's earth, kaolin, and common clay plus shale. End uses as shown on the figure are many.

The process flowsheets, Figures 2 and 3, show the processes used in manufacturing beneficiated clays and bricks. The interior of each of the rectangular "process blocks" appearing on the flowsheet represents at least one of the sequential, real processes of the clay industry. A number and title have been placed within each of the process blocks. These identifying symbols are used in the process descriptions later in this report.

Flag symbols at the upper right-hand corner of the process block indicate the nature of the waste streams, if any, discharged from the process. A circle is used for atmospheric emissions, a triangle for liquid wastes, and a rhombus for solid wastes. The flags do not differentiate between inadvertent (fugitive) and designed wastes.

A verbal process description has been written to characterize each process further, to relate it to other processes, and to quantify its operating parameters.

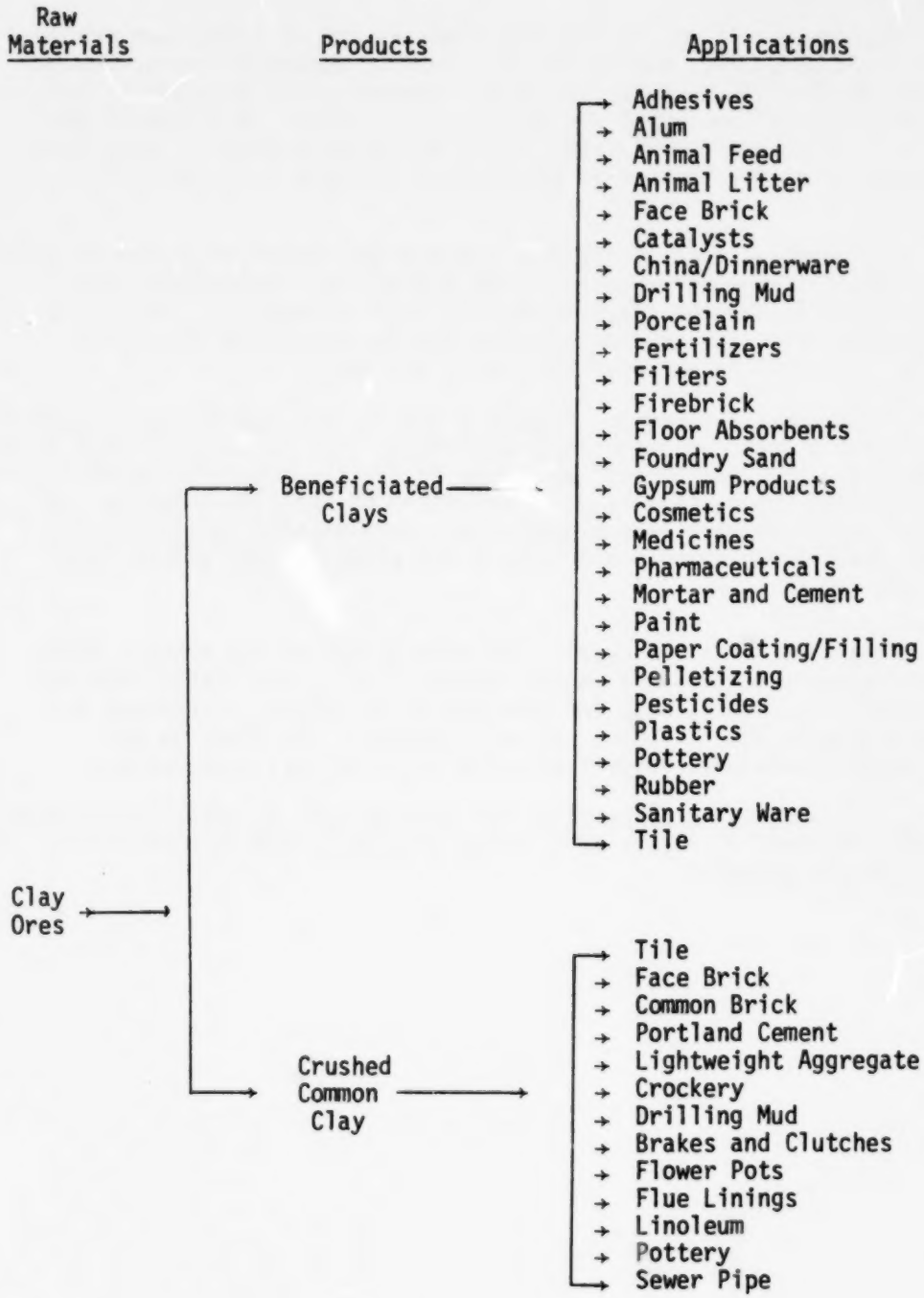

Figure 1. CLAY INDUSTRY CHEMICAL TREE

CLAY PRODUCTION

The Clay Production Segment of the clay industry includes operations involved in mining the clay, beneficiating the clay, and preparing a commercial product. The processes considered are Mining, Crushing, Drying, Dry Grinding, Wet Concentrating, and Final Drying.

Figure 2 is a process flowsheet which characterizes further this segment of the industry.

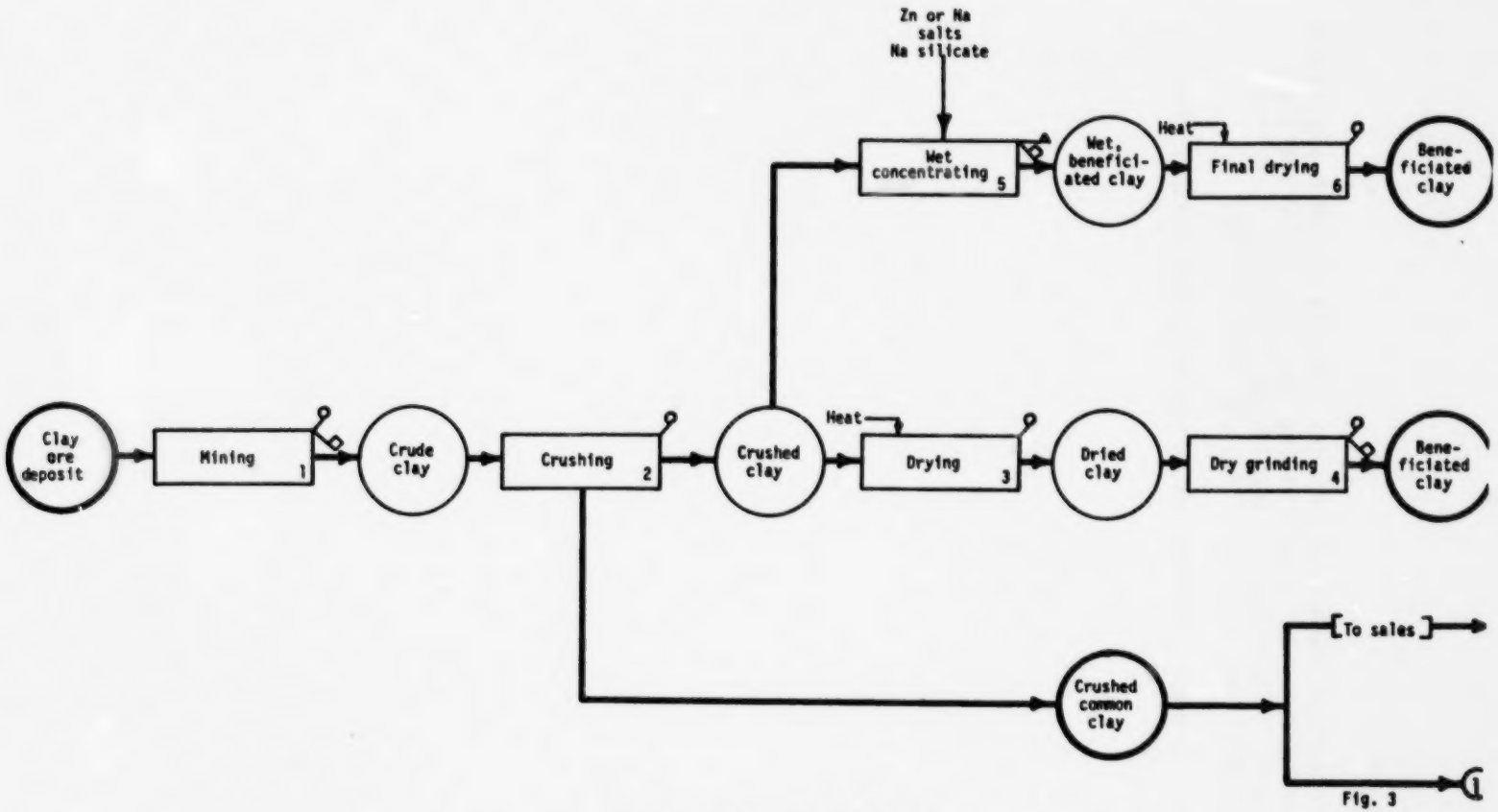

Figure 2. CLAY PRODUCTION FLOWSHEET

MINING

1. Function

This process (See Figure 2) removes clay ore from open-pit mines and forwards it to crushing, Process 2. Overburden is removed and ore extracted using drag lines, mechanical shovels, graders, loaders, and similar equipment. The clay is transported by trucks, conveyor belts, or rail to plant bins or stockpiles. In a few instances other types of mining processes may be used. These processes include underground mining and hydraulic mining. Blasting is occasionally necessary in fire clay mines. Shale planers are sometimes used.

2. Input Materials

- 1 to 10 metric ton clay ore per metric ton clay product.

3. Operating Parameters

- Overburden depth - 1 to 30 meters
- Overburden-to-clay ratios as high as 15:1
- Clay depth - 2 to 15 meters
- Recoverable clay content in ore - 10 to 99 percent

4. Utilities

- Fuel for equipment - 2000 to 15000 kcal per metric ton clay product.

5. Waste Streams

- Dust emissions are estimated to be less than 0.01 metric ton per metric ton clay product.
- Stripped overburden ranges from 1 to 15 metric tons per metric ton clay product.

6. EPA Source Classification Code

None

7. References

Cooper, J. D. Clays. In: Mineral Facts and Problems, Bulletin 630. Bureau of Mines, U. S. Dept. of the Interior. Washington, D. C., U.S. Government Printing Office, 1965. p. 227-240.

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CRUSHING

1. Function

This process (See Figure 2) crushes ore from Process 1 into small lumps and forwards the lumps to Process 3 (drying), Process 5 (wet concentrating), or Process 7, Figure 3 (extruding). Some crushed clay is marketed as a product without further processing.

Primary crushing of fire clay, common clay, and shale is usually done with jaw or gyratory crushers, single roll crusher, or hammer mills. If needed, secondary crushing and grinding are generally by hammer mills, by dry pan, or by wet pan. Secondary crushing is usually followed by screening. Ball clay is usually processed in a shredder. Often bentonite does not require crushing, but goes directly to Process 3. Single-roll crushers are usually used to crush fuller's earth and kaolin. Crushing is followed by screening.

2. Input Materials

- 1 to 10 metric tons clay ore per metric ton clay product.

3. Operating Parameters

- Primary crushing product size - 5 cm maximum
- Secondary crushing product size - 2 cm maximum
- Typical roll size for roll crusher - 1 meter diameter x 0.5 meter length

4. Utilities

- Electrical energy - 1 to 5 kWh per metric ton clay product.

5. Waste Streams

- Dust emissions from crushing are estimated to be less than 0.01 metric ton per metric ton clay product.

6. EPA Source Classification Code

None

7. References

Cooper, J. D. Clays. In: Minerals Facts and Problems, Bulletin 630. Bureau of Mines, U. S. Dept. of the Interior. Washington, D. C., U. S. Government Printing Office, 1965. p. 227-240.

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Robinson, C. G. Clemson University, Personal Communication (August, 1976).

Taggart, A. F. In: Handbook of Mineral Dressing. New York, John Wiley and Sons, Inc., 1945. p. 4-55 to 4-77.

DRYING

1. Function

This process (See Figure 2) receives crushed clay from Process 2 and evaporates water from the clay. The dry clay then goes to dry grinding, Process 4. Bentonite and fuller's earth are often processed in this manner while other clays are often processed in other ways. Clay usually containing 20 to 30 percent water is dried in a rotary dryer. Heated combustion products passing through the dryer evaporate water from the clay. Water content of the exiting clay is 1 to 15 percent. Additional drying usually occurs in Process 4, grinding.

2. Input Materials

- 1.3 to 2 metric tons crushed clay per metric ton clay product.

3. Operating Parameters

- Dryer size - 2.5 meter diameter x 18 meter length
- Dryer thermal efficiency ~50 percent
- Feed rate - 9 metric tons per hour

4. Utilities

- Electrical energy - 1 to 5 kWh per metric ton clay product.
- Dryer fuel - 100,000 to 300,000 kcal per metric ton clay product.

5. Waste Streams

Combustion products may contain hydrocarbons, sulfur oxides, or nitrogen oxides, depending on combustion practices and fuel. With efficient combustion practices and low sulfur fuel the major constituents should be water vapor, carbon dioxide, and nitrogen.

6. EPA Source Classification Code

3-05-008-01 Drying

7. References

Grim, R. E. Applied Clay Mineralogy. New York, McGraw-Hill Book Company, Inc., 1962. p. 381.

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DRY GRINDING

1. Function

This process (See Figure 2) grinds dry or partially dried clay from Process 3 to desired sizes. Bentonite and fuller's earth are usually processed in this manner.

Ball, rod, or roller mills are generally used to grind partially dried clay to specific sizes. Typically a ring-roller mill with an internal Whizzer classifier is used. Hot gases are often introduced to the mill to complete the drying of the clay. The mills are equipped with automatic throwout devices to eliminate oversize impurities such as silica sand. Screening is used to obtain desired size fractions. The resulting products are primarily used as fillers in rubber and paint. They are shipped in bulk or in multi-walled paper bags.

2. Input Materials

- 1.1 - 1.2 metric tons dry or partially dried clay per metric ton clay product.

3. Operating Parameters

- Typical grinding capacity - 3 to 8 metric tons per hour
- Whizzer classifier size - 3 meters diameter
- Typical feed moisture content - 8 to 10 percent
- Typical outlet moisture content - 1 percent
- Product size
  Bentonite fractions ranging from 20-mesh to minus 1500-mesh.
  Fuller's earth fractions ranging from minus 15-mesh, plus 30-mesh to minus 90-mesh.

4. Utilities

- Electrical energy - 25 kWh per metric ton clay product.
- Fuel - 0 to 100,000 kcal per metric ton clay product.

5. Waste Streams

- Dust - 0.05 metric ton dust per metric ton dry product escapes to the air without control. If a cyclone dust collector is used, emissions are reduced to 0.01 metric tons dust per metric ton clay product.

- Solids - 0.05 to 0.2 metric tons coarse impurities per metric ton clay product may be rejected from the clay.

6. EPA Source Classification Code

3-05-008-02 Grinding

7. References

Cooper, J. D. Clays. In: Minerals Facts and Problems, Bulletin 630. Bureau of Mines, U. S. Dept. of the Interior. Washington, D. C., U. S. Government Printing Office, 1965. p. 227-240.

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WET CONCENTRATING

1. Function

This process (See Figure 2) removes impurities from clay coming from Process 2. The purified clay is forwarded to final drying, Process 6. Most kaolin clay is processed in this manner; however, some kaolin is processed by dry processing methods.

Crushed clay (or in some cases hydraulically mined clay) is mixed (blunged) with water in the presence of a dispersing agent such as sodium silicate. The slurry is then purified by letting sand, mica, and other impurities settle in a sedimentation tank. Two size fractions are usually obtained from the purified water-clay suspension using a Hydrosettler or a continuous Sharples or Bird centrifuge. The fine fraction (<1 micron diameter) is used as a pigment and for paper coating while the coarser fraction is used as paper filler. The sized clay may be bleached using zinc or sodium salts to reduce insoluble iron oxides to the ferrous form.

Finally, the clay particles may be pumped as a slurry to drying, Process 6, or they may be collected on plate-and-frame filters or drum filters before drying.

2. Input Materials

- 1.3 to 7 metric tons crushed clay per metric ton clay product.

3. Operating Parameters

- Settling tanks - 200 cubic meters in volume
- Water suspensions carry 5 to 25 percent clay
- Mixer (blunger) size - 2 meters x 3 meters x 6 meters
- Centrifuge size - 2 meters diameter x 2 meters long
- Plate-and-frame filter size - 1 meter x 1 meter
- Filter pressures - start at 0.35 kg per cm^2 and end at 4.2 kg per cm^2

4. Utilities

- Electrical energy - 1 to 3 kWh per metric ton clay product.
- Water - 4 to 20 metric tons per metric ton clay product.

5. Waste Streams

- Solids - 0.1 to 7 metric tons per metric ton clay product.
- Water - 4 to 20 metric tons water per metric ton clay product. This water may contain up to 1 percent suspended clay.

6. EPA Source Classification Code

None

7. References

Grim, R. E. Applied Clay Mineralogy. New York, McGraw-Hill Book Company, Inc., 1962. p. 381.

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FINAL DRYING

1. Function

This process (See Figure 2) dries wet beneficiated clay from Process 5. The dry clay is then ready for shipment.

Filter cake from Process 5 contains approximately 30 percent moisture. It is dried in tunnel or rotary dryers. If heated above 540°C, the clay can be calcined. Clay slurry from Process 5 is dried using spray dryers.

2. Input Materials

- 1.3 metric tons filter cake per metric ton clay product or 2 metric tons clay slurry per metric ton clay product.

3. Operating Parameters

- Rotary dryer size - 2.5 meter diameter x 18 meter length
- Thermal efficiency ~50 percent
- Feed rate - 9 metric tons per hour

4. Utilities

- Electrical energy - 5 kWh per metric ton clay product.
- Fuel - 300,000 to 600,000 kcal per metric ton clay product.

5. Waste Streams

- Combusion product gases may contain hydrocarbons, sulfur oxides or nitrogen oxides, depending on combustion practices and fuel. With efficient combustion practices and low sulfur fuel the major constituents of the combustion gases should be water vapor, nitrogen, and carbon dioxide.

6. EPA Source Classification Code

3-05-008-01 Drying

7. References

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Grim, R. E. Applied Clay Mineralogy. New York, McGraw-Hill Book Company, Inc., 1962. p. 381.

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BRICK MANUFACTURE

The Brick Manufacture Segment of the Clay Industry is very fragmented with over 500 manufacturing plants in operation producing common brick and face brick. The segment is old with well established manufacturing processes. Emissions are not a serious problem in this segment of the Clay Industry.

The process flowsheet of Figure 3 shows brick manufacturing processes. The symbols used in the flowsheet are described in the Industry Analysis section of this report.

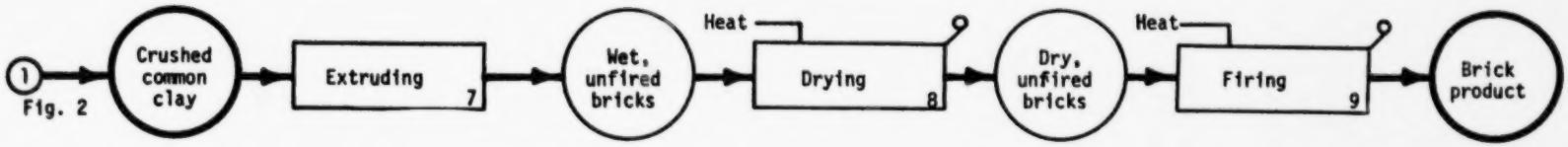

Figure 3. BRICK MANUFACTURE FLOWSHEET

EXTRUDING

1. Function

This process (See Figure 3) extrudes crushed common clay from Process 2, Figure 2, cuts the extrusion into bricks, and forwards the wet, unfired bricks to brick drying, Process 8. If the natural mined clay does not contain enough water for extrusion, crushed common clay is mixed with water in a pug mill and extruded by auger under vacuum to remove air. As the clay is extruded into a ribbon, it is cut into brick sizes, usually with a wire.

2. Input Materials

. 1.2 to 1.3 metric tons wet, crushed common clay per metric ton dried, unfired brick.

3. Operating Parameters

- Vacuum - 6 to 11 cm Hg
- Up to 100 x 10^6 bricks per year per plant

4. Utilities

- Electrical energy - 2 to 5 kWh per metric ton brick product.
- Water - 0.1 metric tons per metric ton brick product.

5. Waste Streams

None

6. EPA Source Classification Code

None

7. References

Norton, F. H. Refractories. New York, McGraw-Hill Book Company, 1968. p. 108-152.

Plummer, H. C. Brick and Tile Engineering Handbook of Design. Washington, D.C., Structural Clay Products Institute, 1950. p. 13-22.

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BRICK MANUFACTURE PROCESS NO. 8

BRICK DRYING

1. Function

This process (See Figure 3) dries wet, unfired bricks from Process 7 and forwards the dry, unfired bricks to firing, Process 9.

Waste heat from the cooling section of the kiln is generally used to dry the bricks. This heated, ambient air is introduced into the dryer. Make-up heat, if needed, may be provided by combustion of fuel. Bricks pass through the dryer on a conveyor and emerge ready for firing, Process 9.

2. Input Materials

- 1.2 to 1.3 metric tons wet, unfired bricks per metric ton dried, unfired brick.

3. Operating Parameters

- Temperature - 100 to 175°C
- Thermal efficiency ~35 percent

4. Utilities

- Fuel - 300,000 kcal per metric ton brick product.

5. Waste Streams

If make-up heat is provided by fuel combustion, the combustion gases may contain sulfur oxides, hydrocarbons, and nitrogen oxides, depending on combustion practices and fuel used. The use of low-sulfur fuels and efficient combustion practices result in mostly water vapor, nitrogen and carbon dioxide in the gases. The dryer exhaust contains about 0.2 kg water vapor per kg dry material.

6. EPA Source Classification Code

None

7. References

Norton, F.H. Refractories. New York, McGraw-Hill Book Company, 1968. p. 108-152.

Plummer, H.C. Brick and Tile Engineering Handbook of Design. Washington, D.C., Structural Clay Products Institute, 1950. p. 13-22.

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FIRING

1. Function

This process (See Figure 3) vitrifies dried bricks from Process 8 to produce a final product.

Dried, unfired bricks are fed through a continuous tunnel kiln or a batch kiln. Refractory-topped cars are used to transport the brick through tunnel kilns. In the continuous process the combustion gases are drawn from the hot section toward the charging section where they are exhausted through the kiln stack. Proper regulation of draft and pressure prevents mixing of combustion gases with the ambient air in the cooling section. In batch kilns the brick are placed in the kiln, fired, cooled, and then removed.

2. Input Materials

- 1 metric ton dried, unfired bricks per 0.92 metric ton brick product.

3. Operating Parameters

- Temperature - 900 to 1430°C
- Firing time - 40 to 250 hours

4. Utilities

- Fuel - 250,000 to 3,000,000 kcal per metric ton brick product.

5. Waste Streams

. Exhaust from the kiln stack contains combustion gases, water, and excess air. The combustion gases may contain sulfur oxides, nitrogen oxides, and hydrocarbons, depending on combustion practices and fuel source. With efficient combustion and low-sulfur fuel the main constituants of the combustion gases should be carbon dioxide, water, and nitrogen.

. Fluorides and sulfur oxides may be exhausted from the clay. The concentrations exhausted vary widely depending on the type of clay being fired.

6. EPA Source Classification Code

None

7. References

Norton, F. H. Refractories. New York, McGraw-Hill Book Company, 1968. p. 192-221.

Plummer, H. C. Brick and Tile Engineering Handbook of Design. Washington, D. C., Structural Clay Products Institute, 1950. p. 13-22.

Handbook of Mineral Dressing. Taggart, A. F. (ed.). New York, John Wiley and Sons, Inc., 1945. p. 17-04 to 17-07.

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APPENDIX A

RAW MATERIAL LIST

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RAW MATERIAL LIST

Ball clay, fire clay, and kaolin are chiefly composed of kaolinite whose structural formula is $Al_4Si_4O_{10}(OH)_8$ or $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. Kaolinite is 45 percent SiO_2, 39 percent Al_2O_3, and 13.6 percent H_2O with lesser amounts (<1 percent) of iron, magnesium, calcium, sodium, and potassium oxides. In addition to kaolinite, ball clay may contain sericite micas and fire clay usually contains other materials such as diaspore, ball clay, bauxite clay, and shale.

Bentonite is chiefly composed of montmorillonite which has a theoretical formula of $(OH)_4Si_8Al_4O_{20}nH_2O$. In reality it always differs from the formula because of substitutions within the lattice of magnesium, iron, zinc, nickel, lithium, and others for aluminum. In addition aluminum or phosphorous sometimes substitutes for silicon.

Most fuller's earth is chiefly composed of attapulgite ($Mg_5Si_8O_{20}(OH_2)_4 \cdot 4H_2O$). Attapulgite is 55 percent SiO_2, 10 percent Al_2O_3, 10.5 percent MgO, 3.5 percent Fe_2O_3, 0.5 percent K_2O, and 20 percent H_2O.

Common clay/shale is chiefly composed of the mineral illite which has the structural formula of $K_2(Si_6Al_2)Al_4O_{20}(OH)_4$.

Brick clays must meet fairly stringent standards relating to manufacturing quality and fired product properties. Illite, kaolinite, or montmorillinite may be the predominant minerals in brick raw materials. Other minerals present are mica, quartz, and feldspar.

Mining and beneficiating of clay minerals produces varying amounts of wastes. Table A-1 contains estimates of raw material usage in 1973.

Table A-1. RAW MATERIALS USED IN 1973

Product	1973 Production (10^6 metric tons)	Typical Waste-to-Clay Ratio	Estimated Total Mined Material (10^6 metric tons)
Common Clay/Shale	45.2	1:4	55 to 60
Kaolin	5.45	7:1	35 to 45
Fire Clay	3.70	1:1	7 to 10
Bentonite	2.79	2:1	7 to 9
Fuller's Earth	1.03	2:1	2.5 to 3.5
Ball Clay	0.70	1:1	1.2 to 1.8
Total	58.9		108 to 130

APPENDIX B

PRODUCT LIST

PRODUCT LIST

Ball clay is defined as a plastic, white-firing clay used principally for bonding in ceramic ware.

Bentonites are composed mainly of the clay mineral montmorillonite. High-swelling or sodium bentonites are produced chiefly in Wyoming, Montana, and South Dakota. Calcium or low-swelling bentonites are produced in other states.

Fire clay is defined as detrital material, either plastic or rock-like, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable the material to withstand temperatures to 1500°C or higher.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate decolorizing and purifying properties.

Kaolin is defined as a white claylike material approximating the mineral kaolinite. It has a specific gravity of 2.2-2.6 and a fusion point of 1785°C. The other kaolin-group minerals, such as halloysite and dickite, are encompassed.

Common clay is defined as a clay or claylike material which is sufficiently plastic to permit ready molding and vitrification below 1100°C. Shale is a consolidated sedimentary rock composed chiefly of clay minerals which has been both laminated and indurated during burying under other sediments.

Table B-1 lists the primary uses for products of the clay industry.

Table B-1. PRIMARY USES OF CLAY PRODUCTS

Product and Uses of Clay in 1973	(% of Product Used in the Application Shown)
Common Clay and Shale	
Brick	45.1
Portland Cement	25.4
Lightweight Aggregate	23.4
Sewer Pipe	3.7
Tile	1.6
Other	0.8
Kaolin	
Paper Coating and Filling	40.6
Brick	6.4
Rubber	6.1
Fire Brick	5.2

Table B-1 (Cont'd). PRIMARY USES OF CLAY PRODUCTS

Product and Uses of Clay in 1973	(% of Product Used in the Application Shown)
Aluminum Sulfate and Other Chemicals	3.8
Fiberglass	3.2
Sanitary Ware	3.0
Refractory Grogs and Crudes	2.6
Paint	2.2
Portland Cement	1.8
Oil Refining Catalysts	1.5
Fertilizers	1.2
Adhesives	1.1
Plastics	1.0
Exports	14.6
Other	5.7
Bentonite	
Foundry Sand	25.7
Iron Ore Pelletizing	25.3
Drilling Mud	18.6
Filtering, Clarifying, Decolorizing	5.5
Animal Feed	4.5
Waterproofing and Sealing	1.9
Pesticides and Related Products	1.2
Exports	14.3
Other	3.0
Fuller's Earth	
Oil and Grease Absorbents	31.3
Pet Absorbent	29.3
Pesticides and Related Products	15.4
Drilling Mud	5.8
Fertilizers	3.4
Filtering, Clarifying, Decolorizing	2.6
Exports	9.7
Other	2.5
Ball Clay	
Sanitary Ware	24.4
Pottery	22.2
Tile	16.2
China/Dinnerware	5.8
Electrical Porcelain	2.2
Brick	1.7
Exports	11.0
Other	16.5

Table B-1 (Cont'd). PRIMARY USES OF CLAY PRODUCTS

Product and Uses of Clay in 1973	(% of product Used in the Application Shown)
Fire Clay	
Firebrick	60.1
Refractory Mortar and Cement	12.7
High-Alumina Refractories	6.2
Foundry Sand	5.6
Refractory Grogs and Crudes	4.4
Sewer Pipe	2.5
Flue Linings	2.2
Tile	1.2
Brick	1.1
Exports	1.0
Other	3.0

APPENDIX C

COMPANIES AND PRODUCTS

Table C-1. KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
American Colloid Corp.	Skokie, Ill				x	
Anglo-American Clays Corp.	Atlanta, Ga.	x				
Ashburg Graphite Mills, Inc.					x	
Ashland Ch. Co., Foundry Prod. Div.	Cleveland, Ohio				x	
Archer, Daniels, Midland Co., Foundry Prod. Div.	Cleveland, Ohio				x	
Alexandria Fire Clay Co.	Alexandria, Pa.			x		
American Clay Forming Plant	Tyler, Texas			x		
Alsey Refractories	Alsey, Ill.			x		
ACF Corp.	Canfield, Ohio			x		
American Industrial Clay Co.	Sandersville, Ga.	x				

Table C-1 (cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	(City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Babcock & Wilcox Refractory Div.	Augusta, Ga.	x				
Baker, J. T. Chem. Co.		x				
Burgess Pigment Co.	Sandersville, Ga.	x				
Bell Clay Co. (TAM Div., NL Industries)	Gleason, Tenn.		x			
Benton Clay Co.	Mills, Wyo.				x	
Black Hills Bentonite Co.	Mills, Wyo.				x	
Cedar Heights Clay Co.	Oak Hill, Ohio	x	x	x	x	
Chemical Heights Clay Co.					x	
Charles B. Crystal Co., Inc.	New York, N.Y.				x	x
C-E Minerals, Div. Comb. Engr.		x		x		
Cyprus Industrial Minerals Co.		x	x	x		

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Can-Tex Industries Div. Harsco Corp.	Mineral Wells, Tex.			x		
Crescent Brick Co.	New Cumberland, W. Va.			x		
Carolina Ceramics, Inc.	Columbia, S.C.			x		
Clay City Pipe Co.	Uhrichsville, Ohio			x		
Corundite Refractors Co.	Massillon, Ohio			x		
Cairo Production Co.	Thomas, Ga.					x
Crossman Co.	Sayreville, N.J.			x		
Chicago Fire Brick Co.	Chicago, Ill.			x		
Ceramic Color & Color Mfg. Co.	New Brighton, Pa.				x	
Chromalloy American Corp.	New York, N.Y.				x	
Dresser Minerals, Div. Dresser Ind.	Houston, Tex.	x			x	

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Dickey, W. S., Clay Mfg. Co.	Kansas City, Mo.			x		
Dando, Frederick J., Co.	Irondale, Ohio			x		
Davis Firebrick Co.	Oak Hill, Ohio			x		
Delhi Foundary Sand Co.	Cincinnati, Ohio			x		
Edgar Plastic Kaolin Co.	Edgar, Fla.		x			
Engelhard Minerals	Decatur, Ga.	x			x	x
Entrada Industries Interstate Brick Div.	Salt Lake City, Utah			x		
El Paso Brick Co.	El Paso, Tex.			x		
Elgin-Butler Brick Co.	Austin, Tex.			x		
Eureka Fire Brick Works	Mt. Braddock, Pa.			x		
Freeport Kaolin Co.	Twiggs, Ga.	x				
Floridin Co.						x

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Freeport Minerals Co.		x				
France, J. H. Refractories	Snoe Shoe, Pa.			x		
Georgia Kaolin Co.	Twiggs, Ga.	x	x	x	x	x
Ga.-Tenn. Mining & Chem. Co.	Jefferson, Ga.					x
Great Lakes Foundry Sand Co.	Detroit, Mich.			x	x	
Green, A. P. Refractories Refractories	Pueblo, Colo.			x		
Garfield Refractories Co.	Bolivar, Pa.			x		
Harbison-Walker Refractories				x		
Harris Mining Co.		x				
Haber, J. M. Corp.	Twiggs & Warren, Ga.	x		x		
Hammill & Gillespie, Inc.		x		x		
Harrison & Crossfield (Pacific, Inc.)		x			x	

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Hickman, Williams & Co.	Chicago, Ill.			x	x	
Haws Refractories Co.	Johnstown, Pa.			x		
Hyzer & Lewellen Co.	Southhampton, Pa.			x		
International Minerals & Chem. Corp.	Libertyville, Ill.			x	x	
Industrial Minerals Corp.			x		x	
Inland Refractories Co.	Cleveland, Ohio		x	x	x	
Keener Sand & Clay Co.	Columbus, Ohio			x	x	
Kaiser Refractories	Oakland, Cal.			x		
Kentucky Tennessee Clay Co.	Mayfield, Ky.			x		
Kaul Clay Co.	Toronto, Ohio			x		
Lawrence Refractories Co.	Pedro, Ohio			x		
Louisville Fire Brick Works	Louisville, Ky.			x		

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Massillon Refractories Co.	Massillon, Ohio			x		
Mid-Florida Mining Co.						x
Meridan Petroleum Co.						x
Milwhite Co., Inc.					x	
Mallinckrodt, Inc.		x				
Mutchler Chem. Co. Inc.		x				
Materials for Industry, Inc.	Ambler, Pa.				x	
Mt. Savage Refractories Co.	Pittsburg, Pa.			x		
McCrody, Inc.	Pittsburg, Pa.			x		
Metropolitan Ind., Inc.	Canton, Ohio			x		
NL Industries, Inc. Baroid Div.					x	
Northern Chem. Inc.					x	

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
NL Industries, Inc. Tam Div.			x	x		
Navron Mining & Chem. Co.			x			
New Castle Refractories Co.	New Castle, Pa.			x		
North American Refractories	Cleveland, Ohio			x		
N. J. Silican Sand	Millville, N.J.			x		
Old Hickory Clay Co.	Paducah, Ky.		x	x		
Oswald Refractories Co.	St. Louis, Mo.			x		
Ohio Fire Brick Co.	Oak Hill, Ohio			x		
Pfizer Minerals, Pigment & Met. Div.					x	
Porth Warner Industries, Inc.			x	x		
Pacific Clay Products	Los Angeles, Cal.			x		
Preskrey Refractories Corp.	Taunton, Mass.			x		

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Peerless Mineral Products Co.	Conneaut, Ohio			x		
Pyro Div.	Oak Hill, Ohio			x		
Pettinos, Geo. F., Inc.	Bala Cynwyd, Pa.			x		
Pembring Mountain Clays Co.					x	
Porter Hk. Co., Inc.	Pittsburg, Pa.			x		
Rowley, Geo. A. & Co.	Philadelphia, Pa.				x	
Royal, H. M., Inc.	Trenton, N.J.				x	
Remmey, Div.	Philadelphia, Pa.			x		
Spinks, H. C. Clay Co.			x		x	
Southeastern Clay Co.		x				
Superior Material Co., Inc.						x
Solomon, L. A. & Bros., Inc.					x	x
Sinclair Mineral & Chem. Co.						x

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Swank Refractories Co.	Johnstown, Pa.			x		
Stevens, Div.	Macon, Ga.			x		
Superior Clay Corp.	Uhrichsville, Ohio			x		
Thompson Hayward Chem. Co.						x
Thiele Kaolin Co.		x				
Thompson-Weinman & Co.		x				
Trans-Oceanic Minerals	Huntington Pk., Cal.				x	
Thor Mining Co.	Thomas, Ga.					x
United Materials & Richmond Brick Co.	Richmond, Calif.			x		
Vanderbilt, R. T. Co., Inc.		x				
Waverly Mining Products	Thomas, Ga.					x
Wyo-Ben Products					x	

Table C-1 (Cont'd). KAOLIN, BALL CLAY, FIRE CLAY, BENTONITE, AND FULLER'S EARTH PRODUCERS

Company	Location (City and State)	Product				
		Kaolin	Ball Clay	Fire Clay	Bentonite	Fuller's Earth
Wilber Ellis Co.					x	
Wellsville Fire Brick Co.	Wellsville, Mo.			x		
Whitehead Bros. Co.	Florham Park, N.J.			x		
Wittekind, N. J. Co.	Cincinnati, Ohio			x		
Woodbury Clay Co.	Hollidaysburg, Pa.			x		
Ferro Corp. Electro Refractories & Abrasives				x		
Georgia Vitrified Brick & Clay Co.	Harlem, Ga.			x		

Table C-2. COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Frame Brick & Title Co., Inc.	Piedmont, Al.
Henry Brick Co., Inc.	Selma, Al.
Jenkins Brick Co., Inc.	Coosada, Al.
Keego Clay Products Co., Inc.	Brewton, Al.
Birmingham Clay Products	Birmingham, Al.
Stephenson Brick & Tile Co.	Birmingham, Al.
Stephenson Brick Co., Inc.	Lovick, Al.
Watkins Brick Co., Inc.	Birmingham, Al.
Huntsville Brick & Tile Co.	Huntsville, Al.
Excelsior Brick Co., Inc.	Montgomery, Al.
Jenkins Brick Co., Inc.	Montgomery, Al.
Alabama Brick & Tile Co.	Decatur, Al.
Bickerstaff Brick Co., Inc.	Phenix City, Al.
Glen Gery Corporation	Cardova, Al.
Watco Corporation	Cordova, Al.
Bickerstaff Clay Products Co.	Birmingham, Al.
Cordova Brick Co., Inc.	Cordova, Al.
Cambell Clinton Construction, Inc.	Phoenix,Az.
Zenith Glazed Products	Tempe, Az.
Grabe Brick Co., Inc.	Tucson, Az.
Tucson Pressed Brick Co.	Tucson, Az.
Wheeler Brick Co., Inc.	Jonesboro, Ar.
Hope Brick Works	Hope, Ar.
Acme Brick Co., Inc.	Perla, Ar.
Acme Brick Co., Inc.	Malvern, Ar.
Malvern Brick & Tile Co.	Malvern, Ar.
Eureka Brick & Tile Co., Inc.	Clarksville, Ar.
First Worth Corp.	Fort Smith, Ar.
First Worth Corp.	Malvern, Ar.
First Worth Corp.	Perla, Ar.
Port Costa Clay Products	Port Costa, Ca.
Craycroft Brick Co., Inc.	Fresno, Ca.
Atkinson Brick Co., Inc.	Los Angeles, Ca.
Davidson Brick Co., Inc.	Los Angeles, Ca.
Landau & Associates, Inc.	Los Angeles, Ca.
San Valle Tile Kilns	Los Angeles, Ca.
Lawrence P. McNear Co.	San Rafael, Ca.
Cannon Brick Co., Inc.	Sacramento, Ca.
California Clay Products	Stockton, Ca.
San Jose Brick & Tile Ltd.	San Jose, Ca.
Kraftile Company	Fremont, Ca.
Sumpf Hans Company	Fresno, Ca.
Castaic Clay Mfg. Co.	Castaic, Ca.
Pacific Clay Products	Los Angeles, Ca.
Selectile Corp., Inc.	La Habra, Ca.
Pacific Clay Products	Alberhill, Ca.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
H. C. Muddox Company	Sacramento, Ca.
Higgins Brick & Tile Co.	Chino, Ca.
Missouri Valley Brick Co., Inc.	San Diego, Ca.
Colorado Brick Company, Inc.	Longmont, Co.
Colorado Brick Co.	Denver, Co.
Denver Brick & Pipe Co., Inc.	Denver, Co.
Robinson Brick & Tile Co.	Denver, Co.
Lakewood Brick & Tile	Lakewood, Co.
Summit Pressed Bric' Tile	Peublo, Co.
Kelsey Ferguson Brick	E. Windsor Hill, Ct.
Michael Kane Brick Co., Inc.	Middletown, Ct.
Plasticrete Corporation	Hamden, Ct.
Plasticrete Corporation	North Haven, Ct.
Delaware Brick Co., Inc.	Wilmington, De.
Deleware Brick Co., Inc.	New Castle, De.
West Brothers Brick Co., Inc.	Washington, D. C.
United Brick Corporation	Washington, D. C.
Alhambra Tile Co., Inc.	Miami, Fl.
Bickerstaff Clay Products	Barth, Fl.
Burns Brick Co., Inc.	Macon, Ga.
Cherokee Brick & Tile	Macon, Ga.
Merry Companies, Inc.	Savannah, Ga.
Chattahoochee Brick Co., Inc.	Atlanta, Ga.
Peavy Concrete Products Div.	Atlanta, Ga.
Plainville Brick Co., Inc.	Plainville, Ga.
Clay Bickerstaff Products	Columbus, Ga.
Georgia Carolina Brick Co.	Augusta, Ga.
Merry Companies, Inc.	Augusta, Ga.
Burns Brick Co., Inc.	Macon, Ga.
Brick Designs, Inc.	Lake Park, Ga.
American Brick Co.	Riverdale, Il.
Brisch Brick Co., Inc.	Chicago, Il.
Illinois Brick Co.	Maywood, Il.
Illinois Brick Co.	Franklin Park, Il.
Illinois Brick Co.	Chicago, Il.
Illinois Brick Co., Inc.	Blue Island, Il.
Structural Glazed Masonry	Chicago, Il.
Clow Corporation	Wheaton, Il.
New Albion Brick Co.	Albion, Il.
Eastern Illinois Clay Co.	Saint Anne, Il.
Galesburg Brick Co.	E. Galesburg, Il.
Hydraulic Press Brick	Streator, Il.
Ristokrat Clay Products Co.	Tonica, Il.
Colchester Brick & Tile Co.	Colchester, Il.
Richards Brick Co., Inc.	Edwardsville, Il.
Hydraulic Press Brick Co.	Aledo, Il.
Hill Brick Co., Inc.	E. St. Louis, Ill.
Clay Products Co., Inc.	Springfield, Il.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Illinois Brick Co.	Danville, Il.
Western Brick Co.	Danville, Il.
Silbrico Corporation	La Grange, Il.
Continental Brick Co.	Albion, Il.
Streator Brick Systems, Inc.	Streator, Il.
Galesburg Brick Co., Inc.	Alton, Il.
Peoria Brick & Tile Co., Inc.	Peoria, Il.
Boston Bricks & Con. Products Co.	Springfield, Il.
Arketex Ceramic Corporation	Brazil, In.
Bloomfield Shale, Inc.	Bloomfield, In.
Majenica Tile Co., Inc.	Huntington, In.
Jackson Brick & Holloware	Brownstown, In.
American Precast Concrete	Indianapolis, In.
American Virtified Product	Crawfordsville, In.
Adams Clay Products Co., Inc.	Martinsville, In.
Martinsville Brick Co., Inc.	Martinsville, In.
Colonial Brick Corporation	Cayuga, In.
Marion Brick Corporation	Brazil, In.
Jackson Brick & Hollow Ware	Brownstown, In.
IU Industrials, Inc.	Crawfordsville, In.
Roll, Inc.	Mason City, Ia.
Redfield Brick & Tile	Redfield, Ia.
Rockford Brick & Tile Co.	Rockford, Ia.
Sheffield Brick & Tile Co.	Sheffield, Ia.
Oskaloosa Clay Products	Oskaloosa, Ia.
Adel Clay Products Co.	W. Des Moines, Ia.
Des Moines Clay Co.	Des Moines, Ia.
Roll, Inc.	Ottumwa, Ia.
Carlisle Brick & Tile Co.	Carlisle, Ia.
Kalo Brick & Tile Co., Inc.	Fort Dodge, Ia.
Kalo Brick & Tile Co., Inc.	Fort Dodge, Ia.
Vincent Clay Products Co., Inc.	Fort Dodge, Ia.
Sioux City Brick Tile Co.	Sioux City, Ia.
Harsco Corporation	Mason City, Ia.
Harsco Corporation	Redfield, Ia.
United Brick & Tile Co.	Abel, Ia.
Goodwin Tile & Brick Co.	Des Moines, Ia.
Harsco Corporation	Des Moines, Ia.
Harsco Corporation	Grimes, Ia.
Roll, Inc.	Des Moines, Ia.
Harsco Corporation	Ottumwa, Ia.
Carlisle Brick & Tile Co.	Carlisle, Ia.
Ballou Brick Co.	Sergeant Bluff, Ia.
Humboldt Brick & Tile Co.	Humboldt, Ks.
Kansas Brick & Tile Co., Inc.	Hoisington, Ks.
Acme Brick Co., Inc.	Weir, Ks.
General Finance, Inc.	Concordia, Ks.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Acme Brick Co., Inc.	Kanopolis, Ks.
Acme Brick Co., Inc.	Buffalo, Ks.
Excelsior Clay Products	Fredonia, Ks.
Big Run Coal & Clay Co., Inc.	Ashland, Ky.
Owensboro Brick & Tile Co.	Owensboro, Ky.
Big Run Coal & Clay	Lexington, Ky.
H. P. Sipple Brick Co., Inc.	Stanton, Ky.
Corbin Brick Co.	Corbin, Ky.
General Shale Products Corp.	Fairdale, Ky.
Bourbon Brick Co.	Lexington, Ky.
Athens Caddo Brick Co.	Mooringsport, La.
Acme Brick Co., Inc.	Baton Rouge, La.
Mike Baker Brick Lafytt	Lafayette, La.
Dixie Brick Inc.	Natchitoches, La.
St. Joe Brick Works, Inc.	Slidell, La.
Hammond Baton Rouge Brick	Hammond, La.
Kentwood Brick & Tile	Kentwood, La.
Mike-Baker Brick Co. New IBR	New Iberia, La.
Mike-Baker Brick Co. New IBR	Cade, La.
La Chance Brothers Brick Co.	Gorham, Me.
Champion Brick Co., Inc.	Baltimore, Md.
Baltimore Brick Co., Inc.	Baltimore, Md.
Chestertown Brick Co., Inc.	Chestertown, Md.
Somerville Thomas Co.	Muirkirk, Md.
Victor Cushwa & Sons, Inc.	Williamsport, Md.
Baltimore Brick Co.	Rocky Ridge, Md.
Maryland Clay Products, Inc.	Beltsville, Md.
Westfield Clay Products Co.	Westfield, Ma.
Stiles & Hart Brick Co.	Bridgewater, Ma.
Dacor Mfg. Co., Inc.	Worchester, Ma.
K-F Brick Co., Inc.	Middleboro, Ma.
Comfort Brick & Tile Co.	Tecumseh, Mi.
Town & Country Face	New Hudson, Mi
American Cement Corp.	Detroit, Mi.
Twin City Brick Co., Inc.	St. Paul, Mn.
OCHS Brick & Tile Co.	Springfield, Mn.
Mississippi Industries	Jackson, Ms.
Tri State Brick & Tile Co.	Jackson, Ms.
Laurel Brick & Tile Co., Inc.	Laurel, Ms.
Brookhaven Pressed Brick	Brookhaven, Ms.
Columbus Brick Co., Inc.	Columbus, Ms.
Clay Products, Inc.	Holly Springs, Ms.
Holly Springs Brick & Tile	Holly Springs, Ms.
Southern Brick & Tile Co.	Byhalia, Ms.
Savery Brick & Tile Co.	Baldwyn, Ms.
Delta Brick & Tile Co., Inc.	Indianola, Ms.
Louisville Brick Co., Inc.	Louisville, Ms.
Delta-Macon Brick & Tile Co.	Macon, Ms.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Masonite Corporation	Shuguolak, Ms.
Columbia Brick & Tile Co.	Columbia, Mo.
Midland Brick & Tile Co.	St. Joseph, Mo.
Acme Brick Co., Inc.	Harrisonville, Mo.
Acme Brick Co., Inc.	Kansas City, Mo.
Midland Brick & Tile Co.	Chillicothe, Mo.
Alton Brick Co., Inc.	Hazelwood, Mo.
Hydraulic Press Brick	St. Louis, Mo.
Endicott Clay Products Co.	Endicott, Nb.
Ferguson & Co., Inc.	Lincoln, Nb.
Western Brick & Supply Co.	Nebraska City, Nb.
Endicott Clay Products Co., Inc.	Fairburg, Nb.
Yankee Hill Brick Mfg. Co.	Lincoln, Nb.
Densmore Brick Co.	Leganon, NH
Kane Gonic Brick Corporation	Gonic, NH
Goodrich, W. S., Inc.	Epping, NH
Alliance Clay Products	Hammonton, NJ
Church Brick Co.	Bordentown, NJ
Alliance Clay Products	Winslow, NJ
Glen Gery Corporation	S. River, NJ
Sayre & Fisher Co., Inc.	Sayreville, NJ
New Jersey Shale Brick	Somerville, NJ
Curran-Pfeiff Corporation	Edison, NJ
Kinney Brick Co.	Albuquerque, NM
Powerll & Minnock Brick Works	Coeymans, NY
Binghamton Brick Co., Inc.	Binghamton, NY
Acme Shale Brick Co., Inc.	Hamburg, NY
Empire Clay Products, Inc.	W. Falls, NY
Nassau Brick Co., Inc.	Farmingdale, NY
Jova Manufacturing Co., Inc.	Kingston, NY
Terry Brick Corporation	Kingston, NY
Harder Silo Co.,	Glens Falls, NY
NL Industries, Inc.	Niagara Falls, NY
Hanford Brick Co., Inc.	Burlington, NC
Sanford Brick Corporation	Gulf, NC
Ideal Brick Co., Inc.	Linden, NC
Cunningham Brick Co., Inc.	Thomasville, NC
Triangle Brick Co., Inc.	Durham, NC
Kendrick Brick & Tile Co.	Mount Holly NC
Boren Clay Products Co., Inc.	Pleasant Gardens, NC
Fletcher Brick Co., Inc.	Fletcher, NC
Statesville Brick Co., Inc.	Statesville, NC
Borden Brick & Tile Co.	Sanford, NC
Lee Brick & Tile Co., Inc.	Sanford, NC
Sanford Brick Corporation	Colon, NC
Kendrick Brick & Tile Co.	Charlotte, NC

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Nash Brick Co., Inc.	Rocky Mount, NC
Pine Hall Brick & Pipe	Madison, NC
Webster Brick Co., Inc.	Eden, NC
Isenhour Brick & Tile Co.	Salisbury, NC
Taylor Clay Products, Inc	Salisbury, NC
Crumpler Brick & Tile Co.	Roseboro, NC
Sanford Brick Corporation	Norwood, NC
Yadkin Brick Yard Inc.	New London, NC
Kendrick Brick & Tile Co.	Monroe, NC
Borden Brick & Tile Co., Inc.	Goldsboro, NC
Cherokee Brick Co. of N.C., Inc.	Moncure, NC
Bennett Brick & Tile Co.	Kings Mt., NC
Borden Brick & Tile Co., Inc.	Durham, NC
Heritage Brick Co.	Lillington, NC
Basic Ceramics, Inc.	Hendersonville NC
Boren Clay Products Co.	Roseboro, NC
Hebron Brick Co., Inc.	Hebron, ND
American Vitrified Products	E. Liverpool Oh.
Metropolitan Industries	Negley, Oh.
Summitville Tiles, Inc.	Summitville, Oh.
Cleveland Builders Supply	Cleveland, Oh.
Cleveland Builders Supply	Bedford, Oh.
Ohio Clay Co., Inc.	Cleveland, Oh.
Galena Shale Tile & Brick	Galena, Oh.
Delaware Clay Co., Inc.	Delaware, Oh.
Claycraft Co., Inc.	Columbus, Oh.
General Hocking Brick Co.	Logan, Oh.
Frederick J. Dano Co.	Irondale, Oh.
Marion Brick Corporation	Morral, Oh.
Marion Brick Corporation	Caledonia, Oh.
Marion Brick Corporation	Marion, Oh.
Belden Brick Co., Inc.	Somerset, Oh.
Ohio Brick & Supply Co., Inc.	Mansfield, Oh.
Richland Shale Brick Co.	Mansfield, Oh.
Alliance Brick Corporation	Alliance, Oh.
Alliance Clay Products Co.	Alliance, Oh.
Belden Brick Co., Inc.	Canton, Oh.
Belden Brick Company	Canton, Oh.
Commercial Plating Div.	Canton, Oh.
Glen Gery Corporation	East Canton, Oh.
Metropolitan Industries	Canton, Oh.
Natco Corporation	East Canton, Oh.
Robertsville Brick	Robertsville, Oh.
Camp Brick Co., Inc.	Mogadore, Oh.
Belden Brick Co., Inc.	Port Washington, Oh.
Claycraft Co., Inc.	Sugarcreek, Oh.
Cleveland Builders Supply	Newcomerstown, Oh.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Evans Brick & Pipe Co.	Midvale, Oh.
Shepfer & Moomaw Brothers, Inc.	Sugarcreek, Oh.
Stone Creek Brick Co., Inc.	Stone Creek, Oh.
Strasburg Brick, Inc.	Strasburg, Oh.
Whitacre-Greer Fireproofing Co., Inc.	Magnolia, Oh.
Whitacre-Greer Fireproofing Co.	Magnolia, Oh.
Belden Brick Co.	Sugarcreek, Oh.
Claycraft Co., Inc.	Sugarcreek, Oh.
Fairfield Brick Co.	Loarville, Oh.
General Clay Products Co.	Baltie, Oh.
Medal Brick, Inc.	Wooster, Oh.
Claycraft Co., Inc.	Upper Sandusky, Oh.
Glen Gery Corporation	Nelsonville, Oh.
Bowerston Shale Co.	Neward, Oh.
General Wadsworth Brick Corp.	Ava, Oh.
Claycraft Co., Inc.	Shawnee, Oh.
Glen Gery Corporation	Magnolia, Oh.
Stark Ceramics	Canton, Oh.
Larson Clay Pipe Co.	Gnadenhutton, Oh.
Sapulpa Brick & Tile Corp.	Sapulpa, Ok.
Mangum Brick Co.	Mangum, Ok.
Acme Brick Co., Inc.	Oklahoma City, Ok.
Superior Clay Products, Inc.	Ada, Ok.
Wewoka Brick & Tile Co.	Wewoka, Ok.
Acme Brick Co., Inc.	Tulsa, Ok.
Fram Corporation	Tulsa, Ok.
First Worth Corp.	Oklahoma City, Ok.
Shawnee Concrete Block & Brick	Wewaka, Ok.
Klamath Falls Brick & Tile	Klamath Falls, Or.
Columbia Brick Works, Inc.	Portland, Or.
Darling Brick Clay Products	Pittsburg, Pa.
Freeport Brick Co.	Creighton, Pa.
Milliken Brick Co., Inc.	Pitcairn, Pa.
Milliken Brick Co., Inc.	Pittsburg, Pa.
Colonial Clay Products Co.	New Brighton, Pa.
Eastvale Clay Products Co.	Beaver Falls, Pa.
Eastvale Stnd. Clay Products	New Brighton, Pa.
General Dynamics Corp.	Darlington, Pa.
Metropolitan Industries	Darlington, Pa.
Glen Gery Corporation	Shoemakersville, Pa.
Glen Gery Corporation	Reading, Pa.
McAvoy Vitrified Brick Co.	Phoenixville, Pa.
Quakertown Brick & Tile Co.	Quakertown, Pa.
Williamsgrove Clay Products Co.	Bigler, Pa.
Glen Gery Shale Brick Corp.	Harrisburg, Pa.
Layton Fire Clay Co., Inc.	Layton, Oh.
Hanley Co., Inc.	Summerville, Pa.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Glen Gery Shale Brick Corp.	Ephrata, Pa.
Lancaster Brick Co., Inc.	Lancaster, Pa.
Fenati Brick Co., Inc.	New Castle, Pa.
Hazelton Brick Co., Inc.	Hazelton, Pa.
Hanley Co., Inc.	Bradford, Pa.
Glen Gery Corp.	Watsontown, Pa.
Watsontown Brick Co., Inc.	Watsontown, Pa.
Auburn Brick Co.	Auburn, Pa.
Otto Brick & Tile Works	Springs, Pa.
Donley Brick Co., Inc.	Washington, Pa.
Monroeville Brick, Inc.	Trafford, Pa.
Glen Gery Shale Brick Corp.	York, Pa.
Alivene Brick Co.	New Oxford, Pa.
Milleken Brick Co.	Cheswick, Pa.
Continental Clay Products Co.	Kittanning, Pa.
New Bethlehem Tile Co., Inc.	New Bethlehem, Pa.
Broad River Brick Co., Inc.	Gaffney, SC
Cheraw Brick Works, Inc.	Cheraw, SC
J. L. Anderson Co.	Cheraw, SC
Salisbury Brick Corp	Summerville, SC
Richland Shale Products Co.	Winnsboro, SC
Angus Brick & Tile Co., Inc.	Ninety Six, SC
Southern Brick Co., Inc.	Ninety Six, SC
Ashe Brick Co., Inc	Van Wyck, SC
Guignard Brick Works, Inc.	Cayce, SC
Pee Dee Ceramics, Inc.	Pee Dee, SC
Richland Shale Products	Columbia, SC
Eastern Brick & Tile Co.	Sumter, SC
Broad River Brick Co.	Blacksburg, SC
Waccamaw Clay Products Co., Inc.	Myrtle Beach, SC
Carolina Ceramics, Inc.	Columbia, SC
Richtex Corp	Columbia, SC
Black Hills Clay Products Co.	Belle Fourche, SD
Clay Gleason Products, Inc.	Nashville, Tn.
W. G. Bush & Co., Inc.	Nashville, Tn.
General Shale Products	Chattanooga, Tn.
Laird Brick Co.	Puryear, Tn.
General Shale Products Corp.	Knoxville, Tn.
Old Hickory Brick Co., Inc.	Greenback, Tn.
General Shale Products Corp.	Kingsport, Tn.
General Shale Products Corp.	Johnson City, Tn.
Gleason Clay Products, Inc.	Gleason, Tn.
W. G. Bush & Co.	Gleason, Tn.
Clay Burn Mfg. Co.	Palestine, Tx.
Elgin Butler Brick Co.	Elgin, Tx.
Elgin Standard Brick Mfg.	Elgin, Tx.
Payne Brick Co.	Elgin, Tx.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Alamo Clay Products Co., Inc.	Elmendorf, Tx.
Texas Brick Co., Inc.	Brownwood, Tx.
Texas Granite Corp.	Marble Falls, Tx.
Saville Baker Brick Co.	Leesburg, Tx.
Martin Brick Co., Inc.	Coleman, Tx.
Ferris Brick Co.	Mesquite, Tx.
Reliance Clay Products Co.	Dallas, Tx.
Acme Brick Co.	Denton, Tx.
Acme Brick Co., Inc.	Ferris, Tx.
Barron Brick Co., Inc.	Palmer, Tx.
Ferris Brick Co., Inc.	Ferris, Tx.
El Paso Brick Co., Inc.	El Paso, Tx.
Teague Brick & Tile Co., Inc.	Teague, Tx.
Acme Brick Co., Inc.	McQueeney, Tx.
Andy Cordell Brick Co.	Houston, Tx.
Houston Brick & Tile Co.	Houston, Tx.
Roy Champiomont Marble	Barker, Tx.
Saville Baker Brick Co.	Houston, Tx.
Marshall Brick Co., Inc.	Marshall, Tx.
Athens Brick Co., Inc.	Athens, Tx.
Texas Clay Products, Inc.	Malakoff, Tx.
Texas Clay Tile, Inc.	Malakoff, Tx.
Wes-Tex Clay Products	Athens, Tx.
Rio Clay Products	Mission, Tx.
San Jose Brick Co.	McAllen, Tx.
Valley Brick & Tile Co.	Mission, Tx.
Barron Brick Co., Inc.	Groesbeck, Tx.
Waco Brick Mfg. Co., Inc.	Waco, Tx.
D Hanis Brick & Tile Co.	D Hanis, Tx.
Acme Brick Co., Inc.	Garrison, Tx.
Whiteselle Brick & Lumber	Corsicana, Tx.
Mineral Wells Clay Products	Mineral Wells, Tx.
Reliance Clay Products, Inc.	Mineral Wells, Tx.
Acme Brick Co., Inc.	Millsap, Tx.
Henderson Clay Products	Henderson, Tx.
Major Brick Co., Inc.	Henderson, Tx.
Reliance Clay Products, Inc.	Lindale, Tx.
Acme Brick Co.	Fort Worth, Tx.
Abilene Brick Co., Inc.	Abilene, Tx.
Laredo Brick & Tile Co., Inc.	Laredo, Tx.
Acme Brick Co., Inc.	Bridgeport, Tx.
Wes-Tex Clay Products Corp.	De Leon, Tx.
Temtex Industries, Inc.	Malakoff, Tx.
Coachman Industries, Inc.	Olney, Tx.
Interstate Brick Co.	Salt Lake City, Ut.
International Pipe Corp.	Ogden, Ut.
Densmore Brick Co.	Essex Junction, Vt.

Table C-2 (Cont'd). COMMON CLAY, BRICK, AND STRUCTURAL CLAY PRODUCERS

Company	Location (City and State)
Brick & Tile Corp.	Lawrenceville, Va.
Daniels Brick & Tile Co.	Richmond, Va.
Redford Brick Co., Inc.	Richmond, Va.
General Shale Products Corp.	Richmond, Va.
Webster Brick Co., Inc.	Suffold, Va.
Webster Brick Co., Inc.	Somerset, Va.
Old Virginia Brick Co., Inc.	Salem, Va.
Locher Brick Co., Inc.	Glasgow, Va.
Webster Brick Co., Inc.	Webster, Va.
General Shales Products	Richlands, Va.
Woodbridge Clay Products Co.	Manassas, Va.
Webster Brick Co., Inc.	Webster, Va.
International Pipe & Ceramics	Seattle, Wa.
Meridian Brick Co., Inc.	Seattle, Wa.
Mutual Materials Co.	Renton, Wa.
Mutual Materials Co., Inc.	Seattle, Wa.
Chehalis Brick & Tile Co.	Chehalis, Wa.
Mutual Materials Co., Inc.	Eatonville, Wa.
Lowell Brick & Tile Co., Inc.	Lowell, Wa.
Lowell Brick Co.	Everett, Wa.
Mutual Materials Co.	Seattle, Wa.
Interpace Corp.	Mica, Wa.
Continental Clay Products	Martinsburg, WV
United Clay Products Co.	Hedgesville, WV
Barboursville Clay Mfg. Co.	Barboursville, WV
Charleston Brick & Tile	Charleston, WV
Capitol Supply Corp.	Weston, WV
Weston Jane Lew Brick Tile	Weston, WV
Koser Silo Works, Inc.	Almena, Wi.
Lowell Clay Products, Inc.	Lovell, Wyo.